

On the Photographs taken at Syracuse during the Eclipse of the Sun, December 22nd, 1870. By Mr. Brothers.

The pre-eminent use of photography for determining points in dispute has seldom perhaps been so plainly seen as in its application to astronomical matters. First of all, in 1860, Dr. De La Rue and Father Secchi settled the question as to the prominences belonging to the Sun; and now, ten years later, it may, I think, be said that photography has disposed of the corona as one of the Sun's appendages.

The variety of drawings which have been published, no two pictures of the same eclipse ever agreeing in all particulars, conclusively showed that to photography must we look if we wished to obtain evidence which should be beyond dispute. The success of Dr. Curtis and Mr. Whipple had proved that more of the corona could be photographed than had previously been shown on the sensitive plate. But much remained to be shown—the eye could see more than had ever been photographed.

In considering the means to be adopted for photographing the eclipse on Dec. 22nd last, the question occurred to me, Why have not the photographic plates shown the corona as it is visible to the naked eye? And the answer appeared to be that the proper kind of instrument had not hitherto been used. An ordinary telescope, whether reflecting or refracting, is not suitable for the purpose. It would be of very little importance whether the image were large or small if only the corona in all its detail could be shown on the collodion plate; and yet the image of the Moon's disk must be of such dimensions that a good enlargement from it could afterwards be made. What was required was a *picture* of the eclipse, and it seemed to me that such a picture could only be taken with an ordinary photographic lens; one of long focus, and yet capable of giving an image with a moderately short exposure. Through the kindness of Mr. Dallmeyer, one of his "Rapid Rectilinear" lenses was lent me for the purpose of the Expedition, and with that instrument my pictures of the corona were taken. This lens is of 4 inches aperture, 30 inches focus, and gives an image of the Sun of about three-tenths of an inch in diameter. The image bears enlargement to $1\frac{1}{2}$ inches diameter with very good definition, notwithstanding the doubling of the image caused by the high wind which was blowing at the time the photographs were taken.

I have no doubt that good pictures of the corona could be obtained with a lens of still shorter focus, better probably than any hitherto taken; and in proof of this I have here three pictures of the eclipse taken by one of my assistants at Manchester with a lens of 16 inches focus and 4 inches aperture, giving an image $\frac{1}{8}$ -inch in diameter. The copies now before you are enlarged four diameters and the definition is good.

It is proposed this evening to show on the screen, by means of the lime-light, transparencies of four of the negatives taken at

Syracuse during the totality. The plates were exposed in the following order, and with the results stated:—

		Seconds of Totality.	Results.
Spare time	3		
First exposure	3	3rd to 6th	Blank
Change plate	6		
Second exposure	18	12th to 30th	Fair
Change plate	6		
Third exposure	30	36th to 66th	Slight
Change plate	6		
Fourth exposure	15	72nd to 89th	Fair
Change plate	6		
Fifth exposure	8	95th to 103rd	Good
Spare time about	3		
Total	104		

The sixth plate taken in the telescope and exposed at the 36th second, for 3 seconds, for the prominences, gave no satisfactory result.

It is extremely difficult to describe the differing appearances of the pictures, but attention may be directed to two or three points. It will be noticed that the cloud which at one time threatened to prevent any photographs being taken, has obscured many of the details which are shown in the fifth plate; but the red prominences, shining with light of much greater photographic intensity than the corona, have left their impressions on the plates, and some of them can be seen in all four. No. 2 has the two between which the great rift shows in the fifth photograph, and these two prominences are shown in all four plates; others were covered by the Moon in passing over the Sun's disk. In No. 3 the light of the corona is about equal on the east and west sides, and is scarcely at all visible on the north and south. In Plates 2, 4, and 5, however, it will be noticed that the preponderance of the corona is seen on the westerly side; and as No. 2 shows this effect, it may, I think, be assumed that it was real, and did not depend on the Moon uncovering the westerly side as she passed on her course.

The effect of the cloud in obscuring detail is seen when we compare No. 5 with the other plates. In this plate we notice as the chief feature a great rift or gap, just between two red prominences on the south-west side of the Moon's limb; and there are also gaps distinctly marked on the east and west sides, with indications of similar features in other places. It may, perhaps, be suggested that these rifts are not visible in any of the other plates because the rifts were formed only at about the time the fifth picture was taken. This cannot, however, have been the case, as the great rift is seen in the same relative position on the plate

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taken by the American photographers at Cadiz, and which was exposed during $1\frac{1}{2}$ minute, or nearly the whole time of the totality. Now if this phenomenon had not been persistent, and only became visible during the last 20 seconds of totality at Cadiz, it could not have been shown at all, as the picture would have been "burnt out" at this part, and no dark space could have been shown.

The great rift in the corona is more distinctly shown in the original negative than in the transparency, which will be exhibited on the screen. The copy is made by transmitting light through the negative, and the consequence is that much of the finer detail is lost. When, however, the negative is viewed by reflected light it is seen that the corona extends on the north and westerly sides to at least two diameters of the Moon, and on the east and south sides to about one diameter.

When the original negative is viewed by transmitted light it exhibits features which I have endeavoured to show, though very imperfectly, in the copy of a drawing which will be exhibited on the screen. There are some places where there has been a greater intensity of light extending in one place about 10' from the Moon's limb, and near this part there are other dense portions of varying height, and these rayed portions of the corona are of various forms, some are slightly curved in one direction and some in another. Most of this detail is lost in the process of copying; the general effect only will be seen on the screen. Photography cannot reproduce its own work in this case; and no words can accurately describe what this negative shows. It may perhaps be possible to reproduce some of the detail in a pencil drawing.

I do not venture to offer any opinion as to the cause of the rifts or dark spaces in the corona, but of their coincidence in position when the various drawings and photographs are placed side by side there cannot be the slightest doubt. This I shall endeavour to show on the screen when it will be noticed that Prof. Watson's drawing, and the American and my own photographs exhibit coincidences of a very remarkable character.

The following remarks on the subject, contained in a letter from Sir J. Herschel, will I am sure be considered valuable:—

"Assuredly the decidedly marked notch or bay in both photographs (those taken at Cadiz and Syracuse) agreeing so perfectly in situation (marked so definitely by its occurrence just opposite the middle point between two unmistakable red prominences) is evidence not to be refused of its extra atmospheric origin, and *almost* conclusive of its proximity to the solar globe. I see nothing which gives me the idea of rays or streaky irradiation such as that figure in the Washington Observations for 1870—Plate XII.—which, if it *could* be believed, would point to lunar mountains as the origin of the dark spaces, and bring the whole phenomenon within the distance of the lunar orbit. A terrestrial atmospheric origin is quite out of question."

On the subject of the effect of the outer corona being due to

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atmospheric glare, I have received the following letter from Prof. Balfour Stewart, who says:—

“In the case of the uneclipsed Sun we have the well-known luminosity surrounding his disk, caused no doubt by atmospheric glare, so that here we may be said to have sunlight *plus* glare; when, however, the Sun is totally eclipsed, the light which we see is derived not from the body of the Sun himself but from his appendages, and the atmosphere acting in the same way upon this light as it did upon that of the uneclipsed Sun we have a complex phenomenon before us consisting of solar appendages *plus* its atmospheric glare.

“Now I see no reason why the proportion between the real light and the glare should not be the same in both these cases; that is to say, light of the Sun *is to* its glare *as* light of the solar appendages *is to* its glare. Taking your photograph as a trustworthy record of what was visible at the late eclipse, let us endeavour to ascertain how much of the photographic effect is due to atmospheric glare. I think I am right in stating two things with regard to this photograph. In the first place, the details of the luminous appendages surrounding the Sun are well represented. Secondly, there is little or no photographic effect over the centre of the Moon’s disk. Judging from the photographs of the Sun himself taken by the Kew heliograph, we may conclude that when those pictures are not overdone, but give the various details of the solar disk, the exposure has been too small to give us the faintest trace of atmospheric glare which surrounds the Sun. Making use of the proportion above stated I should conclude that a photograph of the solar appendages not overdone but presenting, like yours, the details of these appendages, would not present a perceptible trace of their atmospheric glare.

“In the next place, the atmospheric glare due to the light from the eclipsed Sun should be thrown *inwards* over the Moon’s disk as much as *outwards* beyond the true corona, the light therefore which reaches us in a total eclipse from the centre of the Moon’s disk, and which may be partly due to earth-light reflected from the Moon, may be safely taken as somewhat exceeding that which can possibly be due to atmospheric glare; and inasmuch as in your photograph there is very little effect in the centre of the Moon’s disk, I am led to think that very little of the result obtained can be due to glare.

“I have here confined myself strictly to your photographs, but the principle laid down is applicable to all kinds of observations; and I must confess that I cannot at the present moment see why the streamers, if they are caused by the atmosphere, should invariably shoot outwards and never venture to trespass upon the Moon’s disk, at any rate this is a point that will bear discussion.”

A careful examination of the original negative shows that the amount of deposit over the Moon’s disk is equal to that shown at about $1\frac{1}{2}$ diameter from her limb, but this I believe to be due to

chemical deposit, and has nothing whatever to do with the action of light.

When prints from the second and fifth negatives are combined stereoscopically the effect of relief is produced. In the interval of 73 seconds, the Moon has changed her place sufficiently to show that the corona is not an atmospheric phenomenon. If it had not happened that the great rift, occurring between the two prominences shown so distinctly in the American and my own photographs, had decided the solar origin of the corona, these two photographs would probably have been sufficient for the purpose.

On the Zodiacal Light. By A. C. Ranyard, Esq.

The conviction that the accumulation and comparison of evidence on a subject so interesting and yet so little understood as the zodiacal light cannot but be useful, induces me to submit the following observation to the notice of the Astronomical Society:—

On the evening of the 19th December last the detachment of the Eclipse Expedition encamped at Agosta had an opportunity of examining a particularly brilliant display of the zodiacal light, stretching to some 80° from the Sun's place: its contour was of a somewhat conical form, blunted at the apex, the semi-vertical angle of the cone being about 12° . Its light was apparently white, and was undistinguishable in point of colour from the light of the Milky Way, which also shone out with considerable distinctness upon the night in question. I was anxious to see if any polarization could be detected, and for this purpose made use of a Savart, and at first thought that faint lines were visible, indicating polarization in a plane through the Sun; but not being at all sure of my observation, I asked Mr. Burton, who was formerly assistant to Lord Rosse, and has very keen eyesight, to look through the instrument: he at once said that he distinctly saw bands brightest when the Savart was turned so that the direction of the bands passed through the Sun, and that the centre band was black; he also saw the bands perpendicular to the Sun's direction, but could not determine the nature of the centre one. I should mention that the Savart was so set as to give a black centre when the bands were parallel to the plane of polarization.

I then asked Mr. Burton to see if he could detect any bands upon the sky away from the zodiacal light, but he was unable to do so even at 90° away from the Sun's position.

I again took the instrument, but was unable to see any bands myself. On the next night the zodiacal light was again visible, but with considerably less brilliance than before. Father Secchi observed it with a Savart, and thought that he detected faint bands, but said that he could not be sure of his observation.